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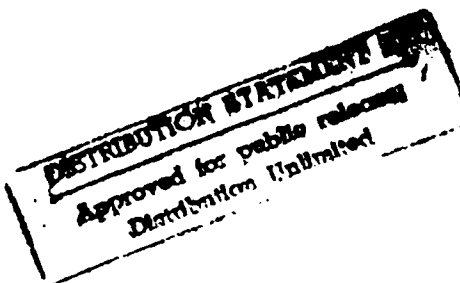
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Final Technical Report, N00014-89-J-1861
Alexander Shor, PI

Support provided under grant N00014-89-J-1861 to Alexander Shor, Associate Geophysicist at Hawaii Institute of Geophysics, was for a collaboration study of the Spitzbergen Margin. The HIG portion of the project supported costs associated with acquisition and processing of SeaMARC II side-scan sonar and swath bathymetric data. Two field programs were successfully carried out in the summers of 1989 and 1990, in collaboration with researchers (funded separately) from Columbia University, University of California San Diego, Naval Research Laboratory, and the University of Bergen (Norway). The project summary prepared for and published by ONR Code 1125GG, is attached here, serving as the Final Technical Report for the HIG grant.

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GEOLOGY AND GEOPHYSICS
PROGRAM SUMMARY FOR
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SEAMARC II INVESTIGATION OF THE NORTHERN NORWEGIAN-GREENLAND SEA: PROGRAM
1990 AND EXPANSION

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Long Range Scientific Objectives

The high-latitude northern Norwegian-Greenland Sea and the adjacent part of the Arctic Ocean north of Spitsbergen comprise an unequaled natural laboratory for the study of several important processes involving the generation and/or modification of sea-floor topography, subbottom structure, and material properties. These processes, active now or in the geologically recent past, include (1) tectonism (faulting), volcanism, magma intrusion into rift valley seafloor sediments; (2) erosion and redeposition of sediment by bottom currents; (3) slumping and other downslope processes on glaciated margins; (4) sedimentation from sea ice/icebergs/ice sheets, at water depths less than 100-500 m, (5) erosion and redeposition by icebergs and grounded ice shelves/sheets. SeaMARC II is the ideal tool for investigating the results of these processes, e.g. the present bathymetric and back-scatter characteristics of the seafloor. The investigation area is probably unique in terms of diversity of processes which can be examined in a relatively small region.

Project Objectives

The area of interest can be subdivided into (A) the active plate boundary; (B) the continental margin; and (C) the Yermak Plateau. Area (A) comprises the median rift valleys of the Mohs, Knipovich and Molloy Ridges and the Spitsbergen-Molloy Transform Faults. This active plate boundary zone features (1) very slow plate motion; (2) dramatic along-strike variations in plate boundary geometry; from normal spreading centers through variously oblique spreading to transform faults; (3) a young ocean basin where the plate boundary is closer to the continental margin than anywhere else in the Atlantic; and (4) a high flux of continent derived glacial sediment into a volcanically/tectonically active rift valley (one of very few examples world-wide). Area (B) is characterized by rapid but variably prograded continental margins heavily influenced by geologically recent glaciation, and possibly bottom currents; Area (C), the Yermak Plateau, is an enigmatic feature of uncertain origin (Iceland-like hot spot volcanism? oceanic crust uplifted as a result of northward propagation of the Knipovich ridge? Thinned, subsided continental crust?) possibly affected by geologically recent volcanism, probably sculpted by bottom currents and ice, and certainly littered with glacial debris.

Of the above problems, the effects of rapid sedimentation on volcanic/tectonic morphology in an active rift valley with high heat flow and probably hydrothermal activity is of primary interest. The acoustic/sedimentological small-scale topographic character and down-slope processes affecting the continental shelf edge-slope-rise system is the second major problem area. Although riverine deltas/fans like the Amazon or Mississippi have been investigated, glacial marine deltas/fans are poorly known. Certainly ice streams which have scoured deep depressions (straths)

across continental shelves must have moved large sediment volumes to the continental margins. The third problem area involves possible seafloor evidence of deep water motion through the Fram Strait (Spitsbergen/Molloy Fracture Zone) area. This is the only deep watergate into the Atlantic Basin and is therefore of great interest for modelling of present and paleo-oceanography and global climate. The 'transensional' separation between Greenland and Svalbard largely in the last 10 m.y. presents researchers with one of the most promising laboratories for studying a specific tectonic influence on climate.

Although plate boundary morphology (e.g. in the floor of the Knipovich rift valley) represents the aggregate effect of sedimentation, tectonism, and magmatic activity over the last 10^5 - 10^6 years, the present state of interglaciation only typifies ca. 10% or less of the last few m.y. The great ice streams which delivered sediment masses to the Isfj rd, Storfj rd and Bj rn ya fans/deltas are not present today, so the processes cannot be studied in vivo. (However, some Svalbard glaciers still actively calve into the heads of their fj rds, allowing real-time studies on a smaller scale). It is also not clear how present deep water flow through the Fram Strait compares to the flow during glacial extrema or deglaciations, or to the average flow. The SeaMARC II evidence RE: bottom currents will have to be evaluated in light of these questions; thus the mosaics assembled will serve to focus subsequent more detailed studies using deep-tow sidescan sonars, bottom photography, and bottom current meters. Similarly the SeaMARC images from the Knipovich-Spitsbergen FZ-Molloy Ridge area and the Yermak Plateau will become the basis for subsequent detailed studies, by future investigations in the same region.

As a first step towards remote classification of seafloor terrain using quantitative seafloor acoustic backscatter measurements made with the SeaMARC II sonar system we also planned to conduct acoustic experiments for a few hours at selected sites during the survey work. The goal was to record SeaMARC II acoustic data in their raw form before they were processed by the SeaMARC II real-time computers aboard ship, so that it would be possible to (1) analyse the system related effects on the acoustic measurements, and (2) test different processing algorithms to try to improve the bathymetric function.

Present Status and Progress During the Current Year

More than 50,000 km² of SeaMARC II imagery was obtained in the northern Norwegian-Greenland Sea and the Arctic Ocean during the months of September and October, 1990. Regions ensonified included the Bj rn ya Fan, two transects near 73 N from the continental margin to the Mohns Ridge, three transects of the Hovgaard Fracture Zone, a S-N section across the Molloy Deep further west than the SeaMARC II coverage of 1989, Two E-W transects of the Yermak Plateau and the continental margin east to 29 E concluding with a zig-zag traverse of the Knipovich Ridge to the Greenland Fracture Zone and back across the Mohns Ridge Bend to the Bj rn ya Fan. Additional coverage of the fan included four N-S tracks culminating in a southwesterly traverse along the Lofoten Margin. Unusual structural, volcanic and erosional features dominate across the Yermak Plateau and the margin off of Nordaustlandet. At least one presumed volcanic cone was mapped adjacent to the eastern margin of the Yermak Plateau directly north of the active volcanic province along the Wook Fj rd on Svalbard. Sonar data reveal high reflectivity flank flows from the base of the seamount which is also marked by a distinctive 200 nT magnetic anomaly over its top. Additional magnetic anomalies in excess of 350 nT are located on highly reflective fault scarps which trend from the Widjefj rd and the Hinlopenstredet into the Arctic Ocean. The highly reflective lineaments are direct extensions of extrusive volcanic provinces located on the margins of the Widjefj rd and the Hinlopenstredet. An Unusually dense network of

sedimentary canyons, perhaps related to recent glacial activity and melting, scour the margin off of Nordaustlandet. Iceberg plough marks were found to criss-cross only the terrain on the western Yermak Plateau. In addition to routine surveying, we carried out acoustic experiments in four locations: in the Molloy Deep, north of Svalbard, across the Knipovich Ridge and along the Bjørnøya Fan. Preliminary results on the phase processing have been presented at the ASA conference in San Diego, 1990.

Publications From Work Completed in FY90

Crane, K., P. Vogt and E. Sundvor, in press, Deciphering the Northern Norwegian-Greenland Sea, McGraw-Hill Yearbook of Science and Technology

Crane, K., E. Sundvor, F. Martinez and R. Buck, in press, Asymmetric Spreading Along the Knipovich Ridge. Evidence for Rifting Along a Detachment Fault? Journal of Geophysical Research

Masnadi-Shirazi, M., and C. de Moustier, 1990, On Differential Phase Measurements with the SeaMARC II Bathymetric Side Scan Sonar System. J. Acous. Soc. Am. V. 88-S1, p. 132.

Okay, N. and K. Crane, in press, Thermal Evolution of the Yermak Plateau, Marine Geophysical Researches

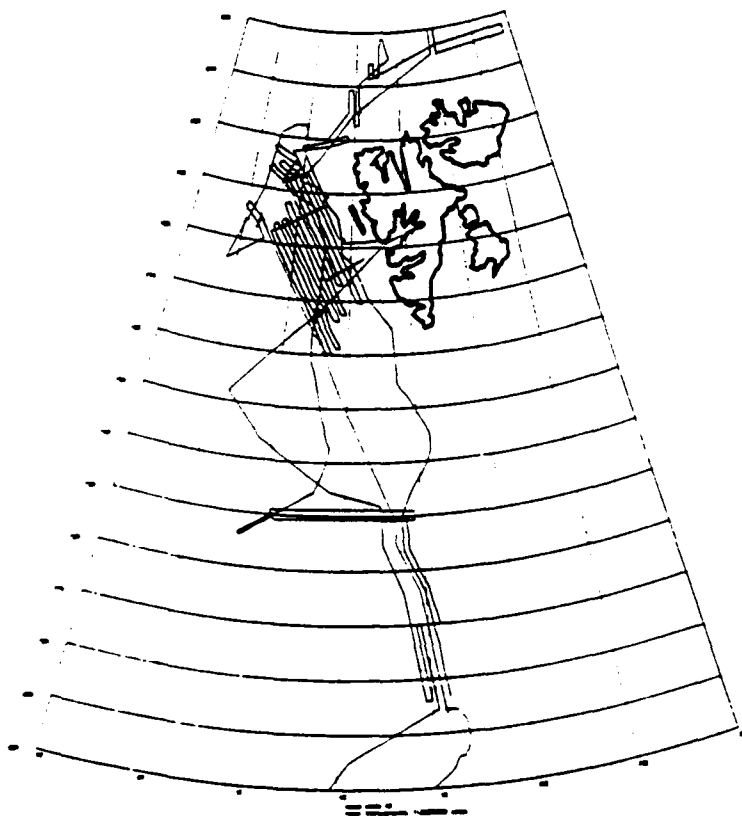


Figure 1. 1989 and 1990 coverage of the Norwegian-Greenland seafloor by the SeaMARC II system.